12/2005

PRECAST CONCRETE TECHNICIAN STUDY GUIDE

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GEORGIA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS AND RESEARCH

STANDARD OPERATING PROCEDURE 3
QUALITY CONTROL AND QUALITY ASSURANCE OF PRECAST/PRESTRESSED CONCRETE MEMBERS AND STRUCTURAL PRECAST CONCRETE MEMBERS

I. GENERAL

This Standard Operating Procedure presents basic principles of a program which insures that precast/prestressed concrete members and structural precast concrete members are produced in compliance with the Plans, approved drawings, and specifications. The Office of Materials and Research will administer the program. Precast/prestressed concrete members and structural precast concrete members produced under this program may be accepted at the jobsite without additional inspection or testing, provided they arrived properly documented and undamaged.

Precast/prestressed concrete members and structural precast concrete members that are used in Department work shall be manufactured at a Certified Plant. Certified Plants are defined as those plants with a Department approved quality assurance program and with an acceptable record of production of quality products. Certified plants will be classified into one of two groups: “A” Plants or “B” Plants.

Classification A Plants are defined as those plants that have a quality control supervisor within the company organization who supervises a Department approved quality assurance program in accordance with the procedures outlined in this SOP.

Classification B Plants are defined as those plants which employ a testing firm or consultant to perform the necessary quality assurance functions. The consultant in charge of quality control will be approved by the Department and shall have the same responsibilities as the quality control supervisor for Class A Plants.

The objective of the program is to assure that only those materials that meet the Department standards are used for Department work and that production procedures produce acceptable concrete members.

Precast/Prestressed Concrete Members and Structural Precast Concrete Members are defined as precast concrete items for bridges and structures produced at a casting facility and transported to the project site and incorporated into the construction work. This Standard Operating Procedure is to be used for both prestressed and non-prestressed concrete members as it applies to each of these different precast items. Items included are precast/pretensioned, precast/posttensioned, precast/pretensioned-post tensioned, precast bridge, and structural precast, concrete members. The terms “precast/prestressed concrete” and “structural precast concrete” hereinafter will be referred to as “concrete members”.

II. PREREQUISITE AND PROCEDURE FOR PLANT CERTIFICATION

Precast/Prestressed and Structural Precast concrete producers must submit a written application for Plant Certification to the State Materials and Research Engineer annually. This application must be submitted no later than December 1 of each year in order to remain an approved source for the following year. This application must include the following items:

1. The company name, the plant address, and the principal officers of the company, including the plant manager, plant engineer, production superintendent, and the quality control supervisor or consultant in charge of quality control.

2. An outline of the producer's quality assurance program. The program must equal the program outlined herein and specify the sampling and acceptance testing frequencies of all materials used in production inspections which insures, (1) stressing compliance, (2) proper tendon and reinforcement location, and (3) dimensional tolerances.

3. A producer's guarantee stating that all concrete members furnished for use in Georgia Department of Transportation projects are warranted to meet the specifications. The certification to be submitted by the producer shall contain the following or similar wording:

> "The undersigned guarantees that all concrete members to be furnished by (Producer) from (Location) for use on Department of Transportation projects in the State of Georgia have been manufactured under strict quality control, and will meet the applicable specifications for the type of concrete member shipped, and that all tests are performed in accordance with the latest AASHTO Standard Methods. (Producer) agrees to have the plant and plant laboratory checked at regular intervals by a representative of the Georgia Department of Transportation, Office of Materials and Research. (Producer)will comply with the Georgia Department of Transportation Standard Operating Procedures for "Quality Control and Quality Assurance of Precast/Prestressed Concrete Members and Structural Precast Concrete Members," Laboratory SOP-3.
>
> The guarantee must be signed by a responsible officer of the company with authority to bind the company to contract and shall be notarized.

Applicants for plant certification must schedule an initial inspection for plant approval with the Department. If the results of the initial inspection and examination indicate an apparent ability to consistently furnish uniform concrete members which conform to the Specifications, the plant may be certified to perform work for the Department.

III. INITIAL INSPECTION AND PLANT CERTIFICATION

The initial plant inspection shall include the approval of quality control personnel to perform the required test, and the inspection of the producer's laboratory and facilities. The inspection will include a review of form condition and dimensions, pallet profile and alignment, concrete batching procedures and plant records and stressing operation for precast/prestressed concrete plants.

A. Quality Assurance

The producer will have a Department approved quality assurance program which shall be operated under the supervision of the quality control supervisor.

1. The quality control supervisor will be responsible for the following functions:
    a. Maintain a materials control program in accordance with schedules outlined herein.
    b. Compensate for free moisture in aggregates, and compensate for the effects of admixtures on concrete mixes.
    c. Control all requisites for concrete mixes and determine their acceptability.
    d. Insure stressing operations conform to specified procedures for precast/prestressed concrete plants.
    e. Inspection of dimensions for positions of bulkheads, strand, reinforcement, inserts, voids, and other integral items.
    f. Inspect the finished product for dimensional accuracy and appearance.
    g. Report deviation from allowable tolerance to the Office of Materials and Research for disposition.
    h. Provide the Office of Materials and Research with documentation of quality control, daily production, and shipping records. Applicable forms for documentation are attached.
2. The quality control supervisor will be examined by the Department for their ability to perform the above functions in accordance with the Department's procedure. This examination will usually be written and oral.
3. Quality control personnel responsible for batching concrete and personnel responsible for sampling and testing fresh concrete (slump, air, temperature and cylinder fabrication) will be examined for their ability to perform these functions. This examination will usually be written and oral.
4. The producer must have a plant Laboratory which is adequately supplied with the equipment necessary to perform the required testing.

B. Casting Beds

Prior to construction of concrete members, the producer is required to submit plans of casting beds to the State Materials and Research Engineer for review of structural stability. The proposed method and equipment for deflected strand hold down anchorages must be included in the precast/prestressed producer's plan.

1. Profile and Alignment

Sufficient pallet supports must be placed at regular intervals transverse to the longitudinal axis of the bed to insure that the pallet remains within a grade tolerance of 1/8 inch per ten feet (3 millimeters per 3 meters) as measured from a plane. If wood supports are used, all supports should be of the same type (dressed or undressed) and kind of wood. This will minimize discrepancies in the pallet profile due to unequal compression, shrinkage, expansion, or deterioration of wood supports. After the pallet and pallet supports are in place, a profile must be taken along the top face of the pallet by the producer. There should be at least one elevation taken for each ten foot (3 meter) length of pallet. Elevations must be taken along both edges of the pallet to reveal any transverse slope. The final results of profiling and correction of pallet grade must produce units that meet tolerances specified herein. Profiles of a pallet grades must be done before the first pour on any new project. For beams and SIP deck panels, the pallet profile shall be done at an interval of every five pours or as needed. For piling, the profile shall be done every two months or as needed. A current plot of the pallet elevations of each individual bed must be on file at the producer's plant. Adequate provisions must be provided for pallet and form expansion and pallets must be anchored to prevent lateral movement.

2. Anchorage System and Strand Location for Precast/Prestressed Concrete Members.

From the pallet profile, the elevation of the individual strands are determined and checked against the strand template of the header assembly.

All anchorage systems must be capable of withstanding 150 percent of the maximum design load with no significant yielding.

C. Stressing Equipment For Precast/Prestressed Concrete Members

All load measuring devices used in stressing must have a current certified calibration. The calibration is to be preformed by an independent calibration company. Certified calibration of dynamometers, load cells, hydraulic gages, and jacking systems, issued by the calibration company, shall be on file for each device at the prestressed plant. All jacks and gages must be recalibrated at six month intervals or as needed to verify accuracy.

D. Concrete Testing Equipment

All concrete testing equipment must be in good working order and free of concrete buildup. Certified calibration of compressive testing machines, issued by the calibration company shall be on file at the precast/prestressed plant. All compressive testing machines must be recalibrated, by an independent calibration company, at twelve month intervals or as needed to verify accuracy.

E. Concrete Plant

The Batch Plant mechanical inspection is to be performed by an independent scale calibration company or may be done by the producer provided it is witnessed by the Office of Materials and Research Plant Inspector. All batching systems for aggregates, cement, water, and admixtures as well as all mixers must comply with Specifications. A certification of plant mechanical acceptability issued by the calibration company must be on file at the plant. This inspection should be made once each four months during construction.

IV. MATERIALS CONTROL PROGRAM

A. Concrete Mix Designs

Concrete mixes must be approved by the Office of Materials and Research. The design of mixes may be done either by a commercial laboratory, or by qualified concrete plant personnel. Concrete mixes must be submitted for review and approval with the annual application for plant certification.

B. Concrete Materials

The sampling and testing of materials must begin early enough to insure acceptability of materials. Department inspectors will secure initial samples to verify the quality of materials as received from the sources. Plant control sampling or testing of materials from approved sources unless noted is not required. Materials shall be sampled and tested in accordance with the following guide:

1. Portland Cement shall be obtained from an approved source. One Independent Assurance sample per month is to be obtained by the Office of Materials and Research Plant Inspector and sent to the Forest Park Laboratory.
2. Fine and coarse aggregates shall be obtained from approved sources. The gradation shall be consistent. One Independent Assurance sample per month is to be obtained by the Office of Materials and Research Plant Inspector and sent to the nearest Office of Materials and Research Laboratory.
3. Admixtures shall be obtained from approved sources. One Independent Assurance sample per year is to be obtained by the Office of Materials and Research Plant Inspector and sent to the Forest Park Laboratory.

C. Steel

1. Tendons

Acceptance of prestressing steel will be made on the results of physical tests made by the Department in addition to a required certification from the manufacturer showing results of the required test, including stress/strain curves.

For pretensioning Steel Wire Strand, two Independent Assurance samples shall be obtained from each heat or lot, five feet (1.5 meters) in length, and transmitted to the Forest Park Laboratory by the Office of Materials and Research Plant Inspector.

2. Reinforcement Steel Bars shall be obtained from approved sources. One Independent Assurance sample per size, per project is to be obtained by the Office of Materials and Research Plant Inspector.

3. Plain Steel Diaphragm Bars, Bolts, Nuts, and Washers

The manufacturer and/or the fabricator shall furnish a certification setting forth the physical and chemical properties of the materials and conformance to the Specifications before they may be used in the work.

D. Bearing Devices

1. Bearing Assemblies, Plates and Hardware

The manufacturer and/or the fabricator shall furnish a certification setting forth the physical and chemical properties of the materials and conformance to the Specifications before they may be used in the work.

2. Elastomeric Bearing Pads

The acceptance of elastomeric pads will be based on the manufacturer's certification showing physical and chemical properties of the materials and conformance with Standard Specifications, Article 885.01, and upon the results of tests performed by the Department on each size and lot.

V. PRODUCTION INSPECTION

Producers are required to provide the State Materials and Research Engineer with the following information well in advance of the fabrication of members:

(1) Shop drawings approved by the Office of Bridge and Structural Design or the Office of Consultant Design, and including for precast/prestressed concrete members, elongation calculations, detensioning pattern, and erection drawings. A complete set of shop drawings bearing the original stamp from a representative of the Office of Bridge and Structural Design or the Office of Consultant Design must be at the plant which is producing the product before any work may begin.
(2) Project number.
(3) Location at which members are to be fabricated.
(4) Probable casting date.
(5) Sources of all materials to be incorporated into the members.
(6) The earliest date prior to fabrication that the facilities may be inspected.

A. Pretensioning for Precast/Prestressed Concrete Members.

1. Threading of Strands and Pre-Loading

   Normally, the first operation will be threading and pre-loading of strands. The application of the pre-load must be observed by the producer's Quality Control Supervisor. The force applied should be concentric with the strand. Strands shall be observed to detect crossed strands.

2. Tensioning Procedure

   The producer's calculations of elongation must be checked by the producer's Quality Control Supervisor and must include allowances for losses due to slippage through grips, and movement of anchorage. When temperature differential between steel at stressing and concrete at placement exceeds 20°F (10°C), a correction in elongation shall be made. The strand stressing operation must be observed and recorded by the producer's Quality Control Supervisor.

   Measurement of elongation shall be the primary control. The hydraulic pressure gauge readings at the time of the measured elongation shall be within 5 percent of the calculated gauge reading. The two measurements shall agree with their computed theoretical values within a tolerance of plus or minus 5%. Additionally, the measurements of force and elongation shall algebraically agree with each other within a 5% tolerance. If the measurements vary by more than 5 percent all work shall be stopped and the defect corrected before proceeding.

B. Placement of Reinforcement Steel, Final Inspection Prior to Concrete Placement

Prior to the placement of the side forms for beams and prior to the placement of concrete for piling and all other members, the producer must provide for a formal inspection of the reinforcement. Sufficient measurements must be made to determine compliance of reinforcement with Plans and Specifications.

C. Placement of Forms

When the side forms have been anchored in position and after all headers have been secured, the producer's quality Control Supervisor shall make a stringline inspection of the forms. A stringline shall be blocked off a uniform distance from one side of an inside face of the side forms. The distance between the stringline and side of the form must be checked at regular intervals. At each interval the width between the inside faces of the forms shall be measured for deviations in alignment. Alignment tolerance shall be a maximum of 1/8 inch per ten feet (3 millimeters per 3 meters) as measured from the stringline. The inside face of the forms must be plumb or at angles established by the Plans. All joints shall be flush with no separations. The headers must be in their correct and final position.

During this inspection, particular attention shall be given to any bearing or embedded plates. They must be in their correct position and anchored so that placement of concrete will not displace them. A final check of strands and reinforcement shall be made to determine that proper concrete cover can be achieved.

D. Concrete Inspection

While the concrete placement operation is in progress, the producer's Quality Control Supervisor shall be instantly available to determine cause and remedy for any undesirable changes which occur in the mix. Each batch of concrete must be judged for acceptance. Uniformity of concrete is of the utmost importance in producing uniform development of strength.

1. Sampling and Testing of Fresh Concrete

   Initial samples of concrete are to be obtained for determining compliance with air content, and slump specifications before any of the concrete is placed.

   A representative sample of concrete shall then be obtained for each placement to conduct a slump test, air content determination, and to manufacture the predetermined number of cylinders. The concrete temperature shall be obtained immediately after sampling. Results of all tests must be recorded immediately after completion of the test.

   The sample of concrete for the test must be selected at random between the first delivery of concrete and the last delivery of concrete. The cylinders must represent the entire period of concrete placement.

   A sufficient number of concrete test cylinders are necessary from each placement of concrete to insure an adequate number of tests for termination of curing, transfer of stress, and erection or driving strength. The exact number of test cylinders and concrete placement procedure will be established for each operation. One set of three 28-day strength cylinders for each day's production must be made and moisture cured by the producer and submitted for test by the Office of Materials and Research.

2. Sequence of Concrete Placement

Inspections by the producer's Quality Control Supervisor must be performed during concrete placement to insure that the placement procedures result in properly consolidated concrete.

a. For Beams: AASHTO Type IV beams and larger sizes shall be placed in a minimum of three lifts; bottom flange, web, and top flange. AASHTO Type III and smaller sized beams may be placed in a minimum of two lifts.

b. For Piling: All solid piles may be placed in one lift. 24 inch (610 millimeter) voided piles may also be placed in one lift. For 30 inch (765 millimeter), 36 inch (915 millimeter) voided piles, the forms must be filled with concrete in two lifts.

c. Bridge Slabs: The placement of concrete shall be performed in a manner that will keep the work alive and free of cold joints. Normally, precast or prestressed bridge slabs are placed in one lift. Voided box beams shall be placed in two lifts. However, no layer shall exceed 24 inches (610 millimeters).

d. Bridge Caps: Bridge caps may be placed in one lift provided the cap depth is not greater than 24 inches (610 millimeters).

e.All Other Members: All other members are to be cast as set forth in the Standard Specification or Special Provision or Plans.

3. Curing Concrete

Special care shall be taken to prevent excessive evaporation or drying out of concrete. The surface of the concrete throughout the curing period shall be covered with a film of free moisture. Curing mats or curing enclosures must completely enclose the members. There must be no gaps or openings in the curing mats or enclosures which allow the concrete surface to become dry. The relative humidity of the atmospheres immediately surrounding the concrete must be maintained at approximately 100 percent.

The producer's method of steam curing must be reviewed to conform to Specification requirements.

E. Surface Finishes

1. Type I Finish

All concrete members shall have an acceptable Type I finish before they are shipped to the project. The initial finish and all pointing shall be completed immediately following the removal of forms.

2. Type III Finish

The Type III finish shall not be attempted until a satisfactory Type I finish has been obtained. Members that require the Type III finish will be given a surface preparation at the casting yard. The Project Contractor will notify the producer when final finish is to be applied at the casting yard to insure compatibility with other finished areas of the structure.

F. Identification of Members

Immediately after the forms have been removed, the members shall be individually identified with an identification number and dated by the producer. This is necessary to insure that a record will be available of the exact location on the bed and date of placement of each member.

G. Transfer of Stress for Precast/Prestressed Concrete Members

The Producer's procedure for transfer of stress must be an approved pattern and schedule of strand release. Particular care should be taken to insure that transfer of stress is in accordance with Specifications.

H. Handling Precast Members

Precast, non-prestress, members shall not be lifted from the casting bed until the concrete has reached a compressive strength as specified on the Plans or at least 1500 psi (10 MPa) nor shall there be any evidence of damage to the unit. Units shall not be transported or erected until they have reached the required design strength.

VI. ACCEPTANCE INSPECTION

A. Dimensional Tolerances

Each member must be checked for construction tolerances by the producer's Quality Control Supervisor. Tolerances, as referenced by the Specifications, are attached.

The limits of tolerances do not necessarily represent fully acceptable construction but are the limits at which construction may become unacceptable. The producer must work at a level of quality that will be well within the tolerance limits.

Concrete cover tests over reinforcement and prestressing steel will be made on each member by the producer's Quality Control Supervisor and on randomly selected members by the Office of Materials and Research Plant Inspector. These measurements will be made with a cover meter and may require selective storage of specific members.

B. Patching and/or Repair

Voids, honeycombs, spalls, damaged areas which are not cause for rejection of the unit must be repaired in accordance with the directions from the Office of Materials and Research Plant Inspector. All spalls, honeycombs, or voids which extend to the reinforcement steel or the prestressed strands are potential cause for rejection and must be brought to the attention of the Office of Materials and Research Plant Inspection Engineer for disposition.

C. Cracks

All cracks must be brought to the attention of the Office of Materials and Research Plant Inspection Engineer for disposition.

D. Storage of Members

Provisions for storage of units must be in accordance with Specification requirements. Storage must be reinspected periodically by the producer's Quality Control Supervisor for adverse changes in dunnage or supports.

VII. ACCEPTANCE IDENTIFICATION

A. Beams

The Office of Materials and Research Plant Inspector will receive notice from the producer prior to shipment of members. All necessary identification must be applied to each member, all finishing and dressing of members must be completed, members must be properly stored and acceptable for shipment and the plant Quality Control stamp on the member before the GDOT stamp can be placed on the member by the Office of Materials and Research Plant Inspector.

B. Piling, Precast or Prestressed Bridge Slabs, Foot Bridges, Caps, and Other Structural Precast Members

The producer need not notify the Department prior to shipment of these members. All necessary markings must be applied to each member, all finishing and dressing must be completed, the members must be properly stored and acceptable for shipment before the company or consulting laboratory stamp is placed on them.

VIII. SHIPPING

A. Loading

Piling must be transported with bolster supports conforming to Georgia Standard No. 3215 and beams must be transported with supports within 3 feet (1 meter) of the bearing area. Bolsters for loading bridge slabs and caps must be spaced at the lifting points. No member shall be shipped from the plant until it carries the official GDOT stamp, the approved company stamp, or the consultant laboratory stamp, whichever is applicable.

B. Project Acceptance

The Project Manager may accept all undamaged members arriving on the project preinspected and "Stamped", provided the members are identified on the accompanying copy of the Office of Materials and Research shipping form. The producer will transmit the original shipping form to the Office of Materials and Research. The form will be reviewed, authenticated, and distributed as the acceptance document for each shipment of members.

IX. DOCUMENTATION

A. Plant Records

The producer is required to have orderly record files maintained and readily available at the plant for inspection. These records are as follows:

1. Maintain test results and test reports on all materials that are used in the work.
2. Maintain records of all stressing operation, pre-load, elongation, and gauge readings for precast/prestressed concrete members.
3. Maintain records of concrete production reports.
4. Maintain accurate records of all members cast and shipped.
5. Maintain records of cover readings.
6. Maintain records of pre-pour and post-pour inspection.

B. Office of Materials and Research Records

The Office of Materials and Research Plant Inspector is required to keep the following records at the Office of Materials and Research:

1. The Office of Materials and Research will maintain records of all plant certifications, quality control personnel and producer's guarantee.
2. Maintain records of test results of all control samples and independent assurance samples.
3. Maintain records of all daily concrete production reports, shipping reports, and materials certifications.

C. Project Records

The Department of Transportation area construction office must keep records for the acceptance of the members and furnished materials.

1. The Project Manager will maintain records of all shipping reports for each shipment of members to the project.
2. Maintain records of all acceptance documents furnished by the Office of Materials and Research.

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Georgene M. Geary, P.E.
State Materials and Research Engineer

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Glenn Durrence, P.E.
Director of Construction

DIMENSIONAL TOLERANCES

FOR MANUFACTURE OF

PRECAST/PRESTRESSED CONCRETE MEMBERS

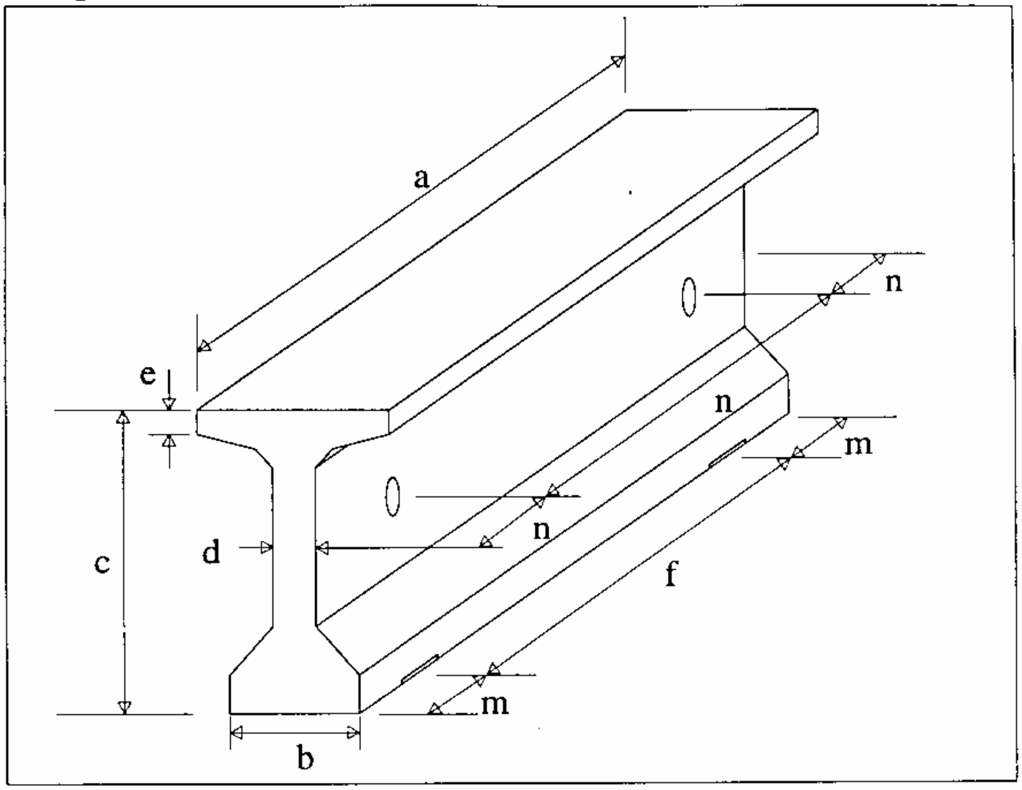
AND

STRUCTURAL PRECAST CONCRETE MEMBERS

DEPARTMENT OF TRANSPORTATION

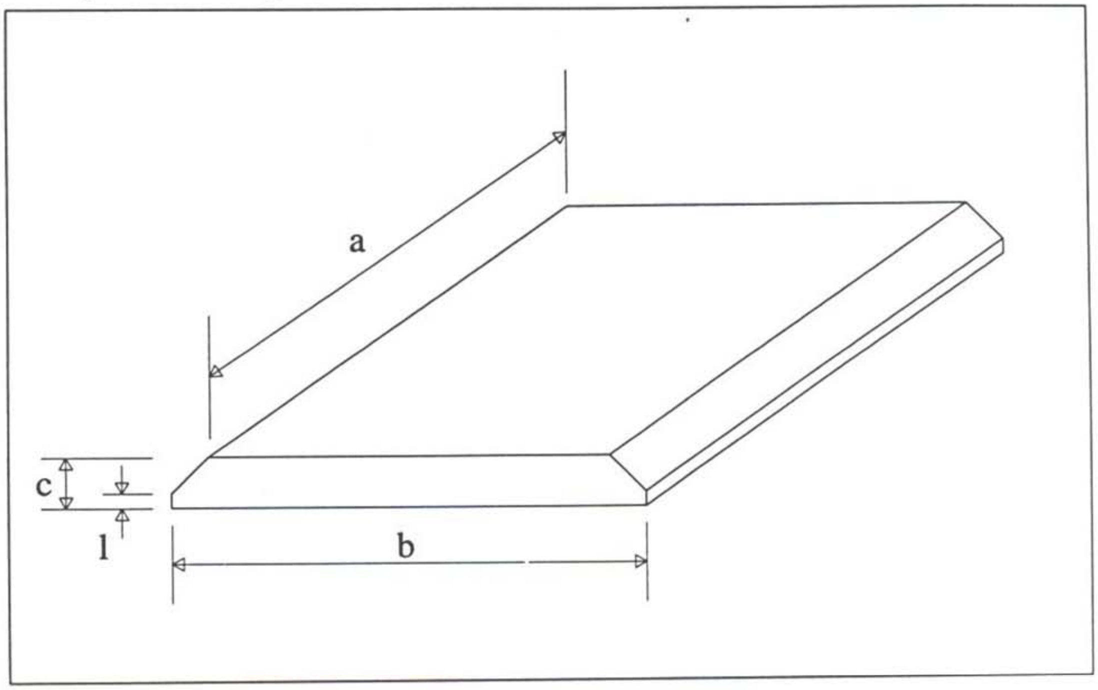
STATE OF GEORGIA
OFFICE OF MATERIALS AND RESEARCH

Bridge I-Beams



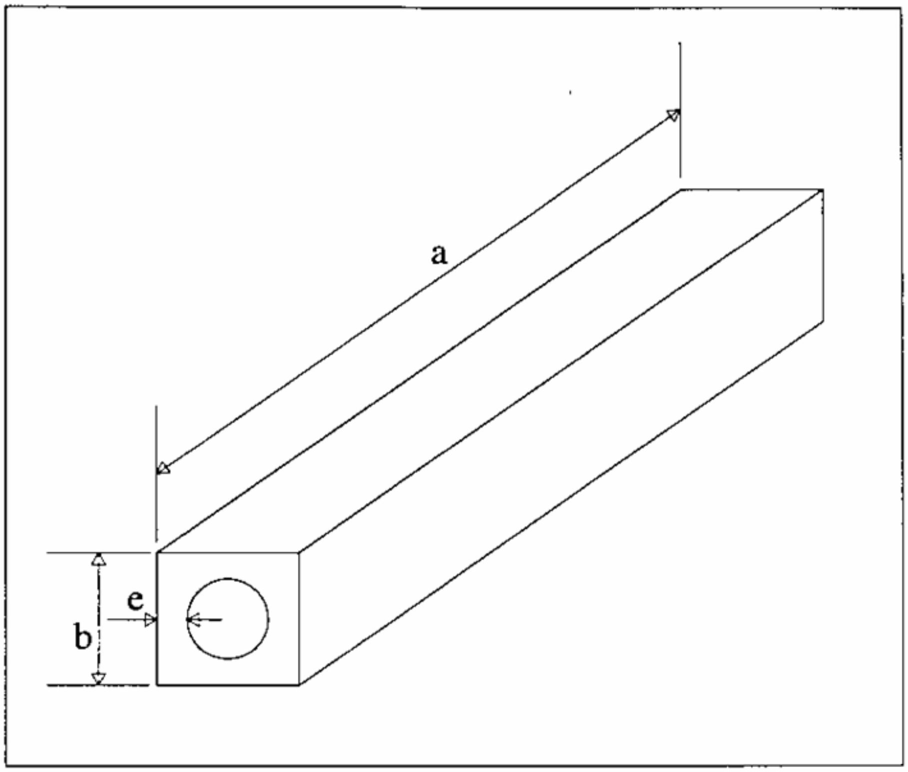
a. Length: ± 3/4 inch (±20 mm)
b. Width (flanges and fillets): +3/8 inch, -1/4 inch (+10 mm, -5 mm)
c. Depth (overall): +1/2 inch, -1/4 inch (+12 mm, -5 mm)
d. Width (web): +3/8 inch, -1/4 inch (+10 mm, -5 mm)
e. Depth (flanges and fillets): ± 1/4 inch (±5 mm)
f. Bearing Plates (center to center): ±1/2 inch (±12 mm)
g. Horizontal Alignment (deviation from straight line parallel to centerline on member)
    1/2 inch for up to 40 foot lengths (12 mm for up to 12 m lengths)
    3/4 inch for 40 to 60 foot lengths (20 mm for 12 m to 18 m lengths)
    1 inch for 60 to 100 foot lengths (25 mm for 18 m to 30 m lengths)
    1 ½ inches for greater than 100 foot lengths (40 mm for greater than 30 m lengths)
h. Camber deviation from design camber: ±1/8 inch per 10 feet (±3 mm per 3 m)
i. Stirrup bars (projection above top of beam): +1/4 inch, -3/4 inch (+5 mm, -20 mm)
j. Tendon position: ±1/4 inch (5 mm) center of gravity of strand group and individual tendons
k. Position of deflection points for deflected strand: ±6 inches (±150 mm)
l. Position of handling devices: ±6 inches (±150 mm)
m. Bearing plates (center to end of beam): ±1/4inch (±5 mm)
n. Tie rod holes (center to center and center to end): ±1 inch (±25 mm)
o. Exposed beam ends (deviation from square or designated skew)
    Horizontal: ±1/4 inch per foot (5 mm per meter) of beam width
    Vertical: ±1/8 inch per foot (3 mm per meter) of beam depth
p. Bearing area deviation from plane: ±1/8 inch (±3 mm)
q. Stirrup Bars (longitudinal spacing): ±1 inch (±25 mm)
r. Position of post tensioning duct: ±1/4 inch (±5 mm)
s. Position of weld plates: ±1 inch (±25 mm)

Composite Bridge Deck Panels or SIP (Stay in Place) Panels



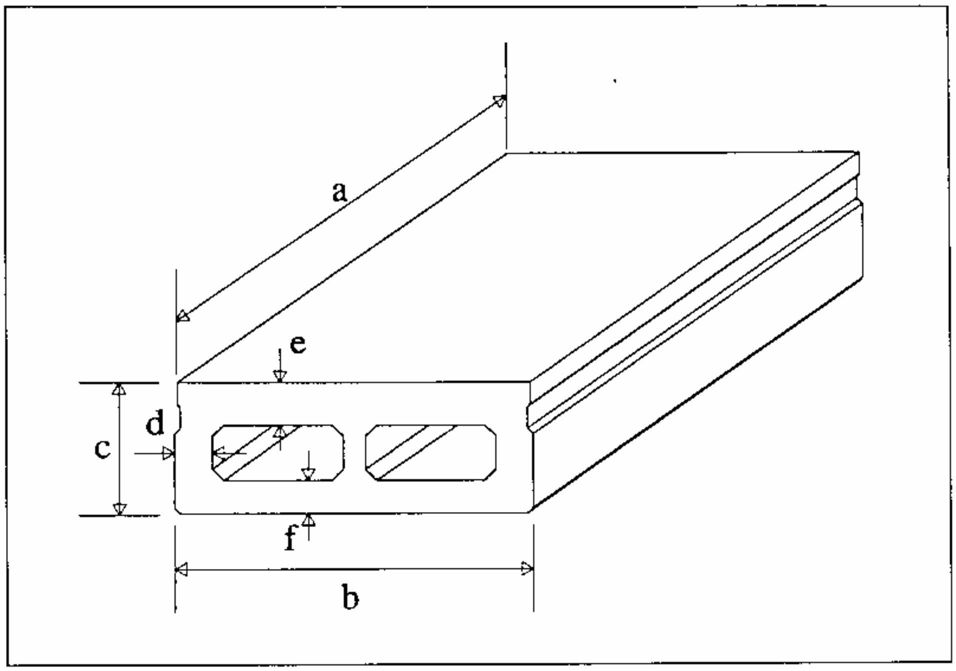
a. Length: ±1 inch (±25 mm)
b. Width: ±1/4 inch (±5 mm)
c. Depth: +1/8 inch, -1/4 inch (+3 mm, -5 mm)
d. Position of strand (vertical): ±1/8 inch (±3 mm)
e. Position of strand (horizontal): ±1/2 inch (12 mm)
f. Position of ribs: ±1/4 inch (±5 mm)
g. Position of handling devices: ±6 inches (±150 mm)
h. Position of weld plates: ±1 inch (±25 mm)
i. Camber deviation from design camber: ±1/8 inch per 1 feet (±3 mm per 3 m)
j. Differential vertical offset between adjacent members of the same design:
   1/4 inch per 10 feet, but not greater than 1/2 inch
   (6 mm per 3 m, but not greater than 12 mm)
k. Squareness of ends (vertical and horizontal alignment): ±1/2 inch (12 mm)
l. Mating surface: 1 inch (25 mm) maximum, 1/4 inch (5 mm) minimum
m. Mating surface deviation from a straight line: ±1/8 inch per 10 feet (±3 mm per 3 m)

Piling, Solid or Voided



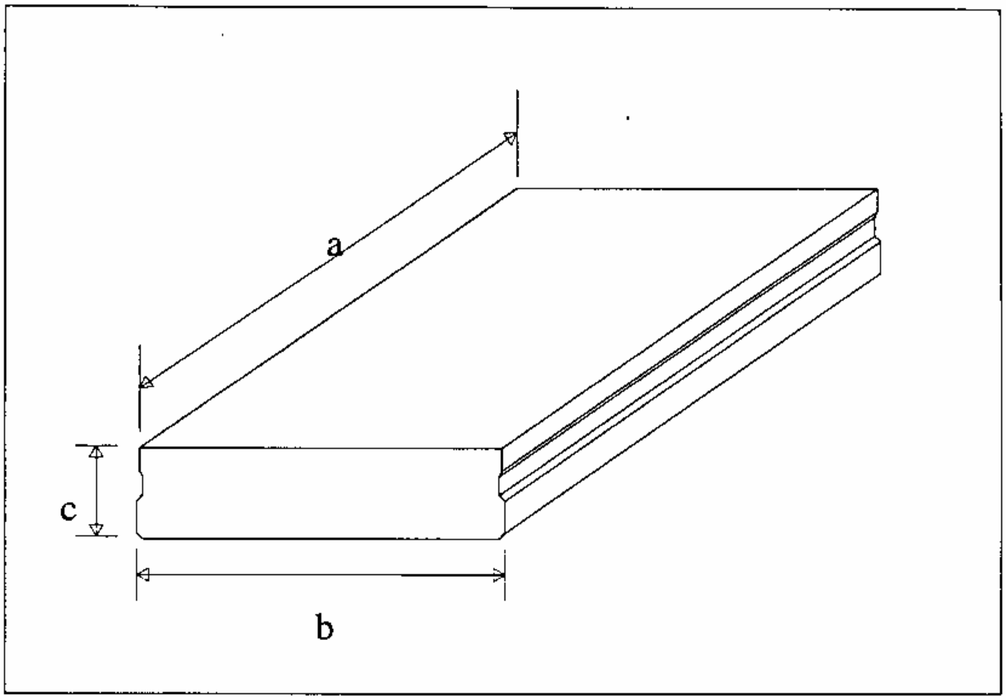
a. Length: ±1 inch (25 mm)
b. Width or Diameter: -1/4 inch, +3/8 inch (-5 mm, +10 mm)
c. Head out of square: 1/8 inch per 12 inch of width (3 mm per meter of width)
d. Horizontal alignment (deviation from straight line parallel of centerline of pile)
   1/8 inch per 10 feet of pile (3 mm per 3m of pile)
e. Position of void: ±1/2 inch (±12 mm)
f. Position of stirrup bars and spirals: ±3/4 inch (±20 mm)
g. Position of tendons: ±1/4 inch (±5 mm)
h. Position of handling devices: ±6 inches (150 mm)
i. Position of steel driving tips: ±1/2 inch (±12 mm)

Bridge Box Beams

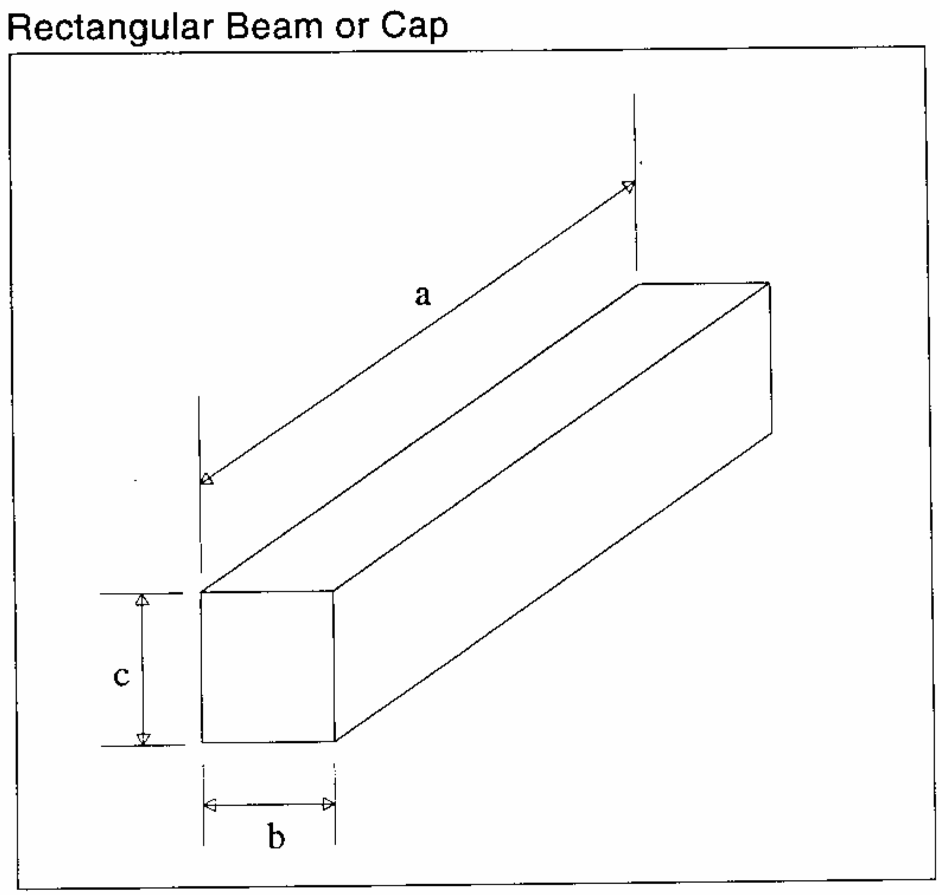


a. Length: +0 inch, -3/4 inch (+0 mm, -20 mm)
b. Width (overall): ±1/4 inch (±5 mm)
c. Depth (overall): ±1/4 inch (±5 mm)
d. Width (web): ±3/8 inch (10 mm)
e. Depth (top slab): ±1/2 inch (±10 mm)
f. Depth (bottom slab): +1/2 inch, -1/8 inch (+12 mm, -5mm)
g. Horizontal alignment (deviation from straight line parallel to centerline of member)
   3/8 inch for up to 40 foot lengths (10 mm for up to 12 m lengths)
   1/2 inch for 40 to 60 foot lengths (12 mm for 12 m to 18 m lengths)
   3/4 inch for greater than 60 foot lengths (20 mm for greater than 18 m lengths)
h. Camber deviation from design camber: ±1/8 inch per 10 feet (±3 mm per 3 m)
i. Differential vertical offset between adjacent units:
   1/4 inch per 10 feet, but not greater than 3/4 inch
   (6 mm per 3 m, but not greater than 20 mm)
j. Position of tendons: ±1/4 inch (±5 mm)
k. Position of stirrup bar: ±1 inch (±25 mm)
l. Position of handling devices: ±6 inches (±150 mm)
m. Slab void position:
   ±1/2 inch (12 mm) from end of void to center tie hole, ±1 inch (25 mm) adjacent to end block
n. Square ends (deviation from square): ±1/4 inch (±5 mm)
o. Skew ends (deviation from designated skew): ±1/2 (±12 mm)
p. Beam seat bearing area (variation from plane surface when tested with a straightedge):
   ±1/8 inch (±3 mm)
q. Dowel tubes (spacing between the centers of tubes and from the centers of tubes to the end of the member): ±1/2 inch (±12 mm)
r. Tie rod tubes (spacing between the centers of tubes and from the centers of tubes to the end of the member): ±1/2 inch (±12 mm)
s. ±1/2 inch (±12 mm)
t. Total width of deck: Theoretical width +1/2 inch (+12 mm) per joint
u. Position of side inserts: ±1/2 inch (±12 mm)
v. Position of weld plates: ±1 inch (±25 mm)

Flat Slab Deck Units

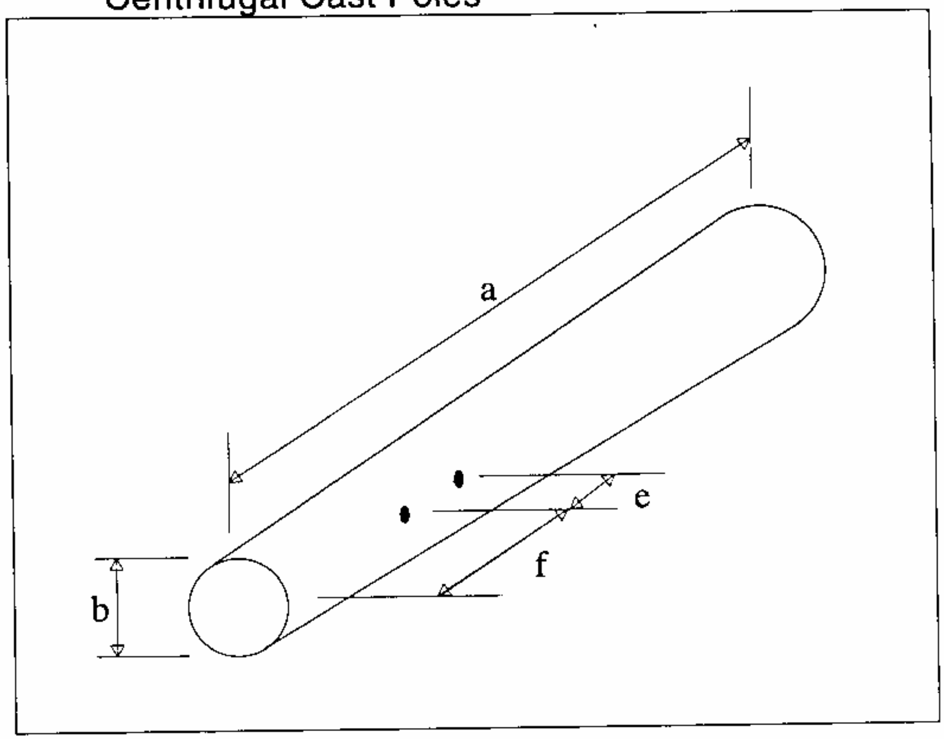


a. Length: +0 inch, -3/4 inch (+0 mm, -20 mm)
b. Width: ±1/4 inch (±5 mm)
c. Depth: ±1/4 inch (±5 mm)
d. Position of voids (vertical): ±1/4 inch (±5 mm)
e. Position of voids (horizontal): ±1/4 inch (±5 mm)
f. Position of tendons: ±1/4 inch (±5 mm)
g. Position of handling devices: ±6 inches (±150 mm)
h. Position of weld plates: ±1 inch (±25 mm)
i. Camber deviation from design camber: ±1/8 inch per 10 feet (±3 mm per 3 m)
j. Differential vertical offset between adjacent members of the same design:
   1/4 inch per 10 feet, but not greater than 3/4 inch
   (6 mm per 3 m, but not greater than 20 mm)
k. Squareness of ends (vertical and horizontal alignment): ±1/4 inch (±5 mm)
l. Bearing area (variation from plane surface when tested with a straightedge): ±1/8 inch (±3 mm)
m. Dowel tubes (spacing between the centers of tubes and from the centers of tubes to the ends and sides of member): ±1/2 inch (±12 mm)
n. Tie rod tubes: ±1/2 inch (±12 mm)
o. Horizontal alignment (deviation from straight line parallel to centerline of member):
   1/8 inch per 10 feet, but not greater than 3/8 inch
   (3 mm per 3 m, but not greater than 10 mm)



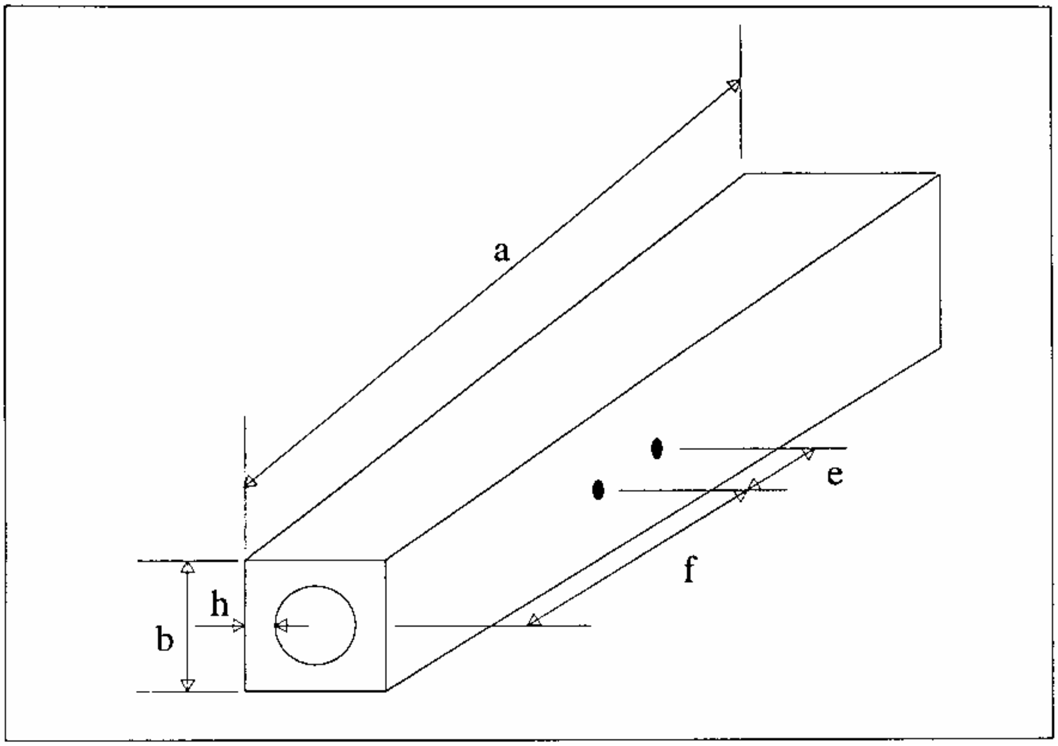
a. Length: ±3/4 inch (±20 mm)
b. Width: ±1/4 inch (±5 mm)
c. Depth: ±1/4 inch (±5 mm)
d. Horizontal alignment (deviation from straight line parallel to centerline of member)
   3/8 inch for up to 40 foot lengths (10 mm for up to 12 m lengths)
   1/2 inch for 40 to 60 foot lengths (12 mm for 12 m to 18 m lengths)
   3/4 inch for greater than 60 foot lengths (20 mm for greater than 18 m lengths)
e. Camber deviation from design camber: ±1/8 inch per 10 feet (3 mm per 3 m)
f. Position of tendons: ±1/4 inch (±5 mm)
g. Position of handling devices: ±6 inches (±150 mm)
h. Position of deflection point for deflected strands: ±6 inches (±150 mm)
i. Position of weld plates: ±1/2 inch (±12 mm)
j. Squareness of ends (vertical and horizontal alignment): ±1/4 inch (±5 mm)
k. Beam seat bearing area (variation from plane surface when tested with a straightedge): ±1/8 inch (±3 mm)
l. Dowel tubes (spacing between the centers of tubes and from the center of tubes to ends and sides of members): ±1/2 inch (±12 mm)
m. Position of stirrup bars: ±1 inch (25 mm)
n. Position of bearing plates: ±1/4 inch (±5 mm)
o. Bearing surface deviation from specified plane: ±1/8 inch (±3 mm)

Concrete Strain Poles
Centrifugal Cast Poles



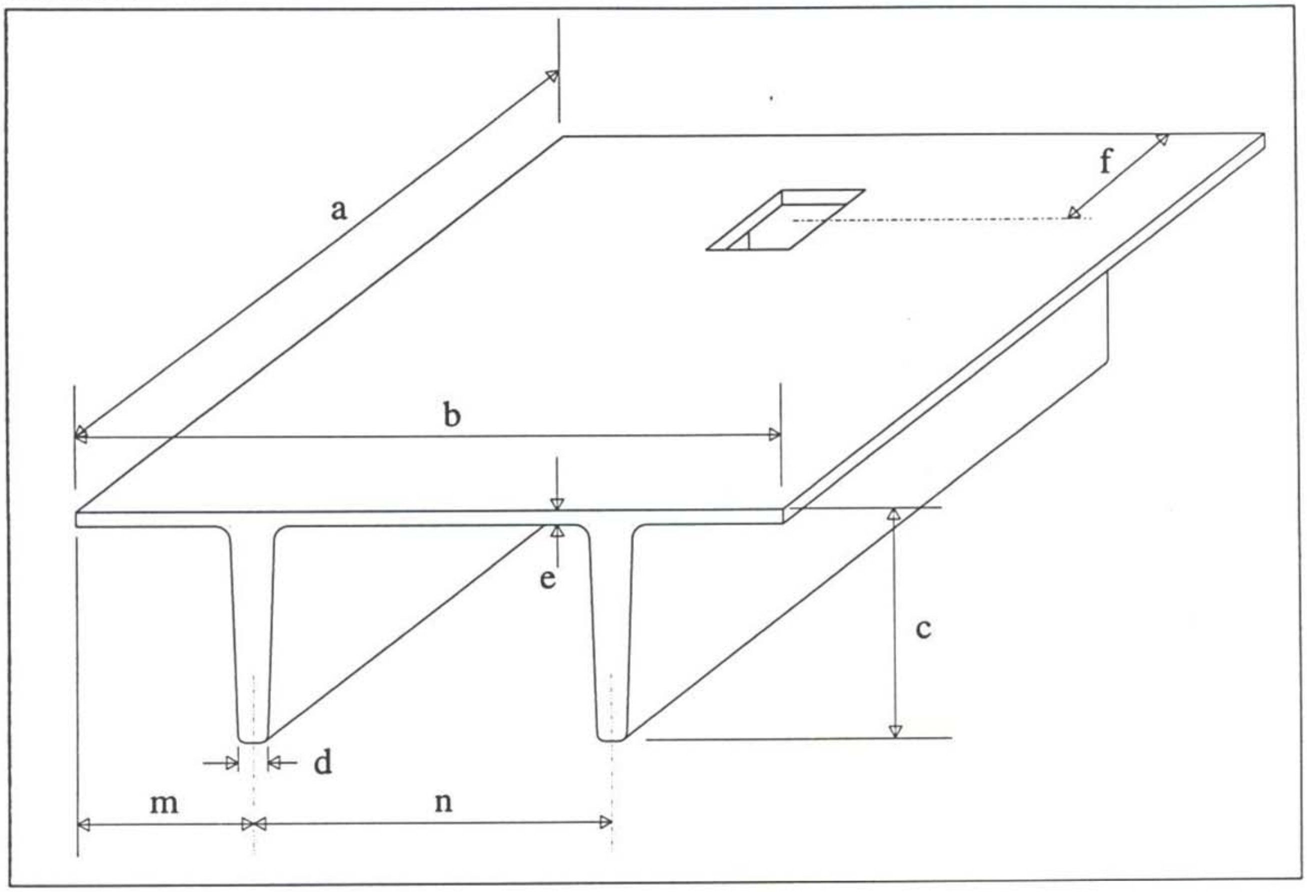
a. Length: ±3 inch (±75 mm)
b. Width of diameter: ±5/8 inch (±15 mm)
c. Sweep: 3/8 inch per 10 feet (±10 mm per 3 m)
d. Position of tendons: ±1/4 inch (±5 mm)
e. Position of paired holes: ±1/8 inch (±3 mm)
f. Position of individual or paired holes from tip: ±1 inch (±25 mm)
g. Blockouts: ±1 inch (±25 mm)
h. Tip wall thickness: +1/2 inch, -1/4 inch (+12 mm, -5 mm)
i. Butt wall thickness: ±1 inch (±25 mm)

Concrete Strain Poles
Static Cast Poles



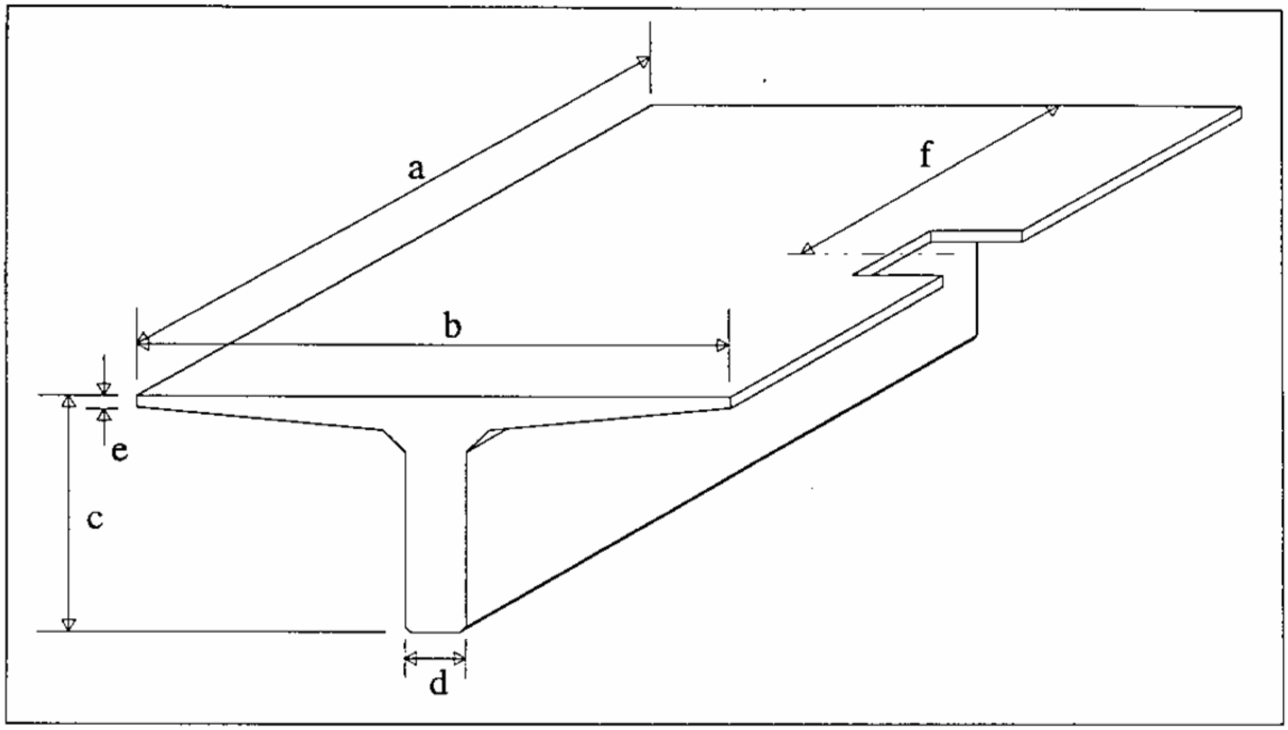
a. Length: ±3 inch (±75 mm)
b. Width of diameter: +5/8 inch, -1/4 inch (+15 mm, -5mm)
c. Sweep: 3/8 inch per 10 feet (±10 mm per 3 m)
d. Position of tendons: ±1/4 inch (±5 mm)
e. Position of paired holes: ±1/8 inch (±3 mm)
f. Position of individual or paired holes from tip: ±1 inch (±25 mm)
g. Blockouts: ±1 inch (±25 mm)
h. Position of void: ±1 inch (±25 mm)

Double Tee



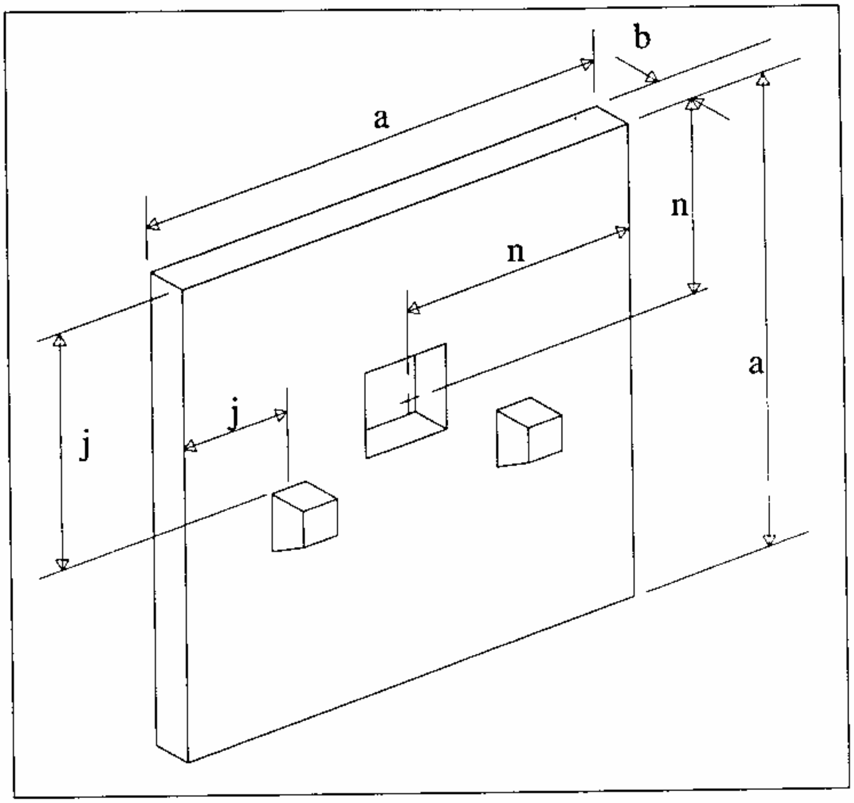
a. Length ±1/2 inch (±12 mm)
b. Width (overall): ±1/4 inch (±5 mm)
c. Depth: ±1/4 inch (±5 mm)
d. Stem thickness: +1/4 inch, -1/8 inch (+5 mm, -3mm)
e. Flange thickness: +1/4 inch, -1/8 inch (+5 mm, -3mm)
f. Position of blockout: ±1/2 inch (±12 mm)
g. Horizontal alignment (deviation from straight line parallel to centerline of member):
   1/4 inch for up to 40 foot lengths (5 mm for up to 12 m lengths)
   3/8 inch for 40 to 60 foot lengths (10 mm for 12 m to 18 m lengths)
   1/2 inch for greater than 60 foot lengths (12 mm for greater than 18 m lengths)
h. Camber deviation from design camber:
   ±1/4 inch per 10 feet, but not greater than ±3/4 inch (±5 mm per 3 m, but not greater than ±20 mm)
i. Differential camber between adjacent members of the same design:
   ±1/4 inch per 10 feet, but not greater than ±3/4 inch (±5 mm per 3 m, but not greater than ±20 mm)
j. Position of tendons: ±1/8 inch (±3 mm)
k. Position of handling devices: ±6 inches (±150 mm)
l. Position of deflection points for deflected strand: ±6 inches (±150 mm)
m. Stem to edge of top flange: 1/8 inch (±3 mm)
n. Distance between stems: 1/8 inch (±3 mm)
o. Position of weld plates: ±1 inch (±25 mm)
p. Squareness of ends (vertical and horizontal alignments) ±1/4 inch (±5 mm)
q. Bearing plates (center to end) ±1/2 inch (±12 mm)

Single Tee



a. Length: ±3/4 inch (±20 mm)
b. Width (overall): ±1/4 inch (±5 mm)
c. Depth: ±1/4 inch (±5 mm)
d. Width (stem): ±3/16 inch (±5 mm)
e. Flange thickness: +1/4 inch, -1/8 inch (+5 mm, -3 mm)
f. Position of blockouts: ±1/2 inch (±12 mm)
g. Horizontal alignment (deviation from straight line parallel to centerline of member):
   1/4 inch for up to 40 foot lengths (5 mm for up to 12 m lengths)
   3/8 inch for 40 to 60 foot lengths (10 mm for 12 m to 18 m lengths)
   1/2 inch for greater than 60 foot lengths (12 mm for greater than 18 m lengths)
h. Camber deviation from design camber:
   ±1/4 inch per 10 feet, but not greater than ±3/4 inch (±5 mm per 3 m, but not greater than ±20 mm)
i. Differential camber between adjacent members of the same design:
   ±1/4 inch per 10 feet, but not greater than ±3/4 inch (±5 mm per 3 m, but not greater than ±20 mm)
j. Position of tendons: ±1/4 inch (±5 mm)
k. Position of handling devices: ±6 inches (±150 mm)
l. Position of deflection point for deflected strand: ±6 inches (±150 mm)
m. Position of weld plates: ±1 inch (±25 mm)
n. Squareness of ends (vertical and horizontal alignment): ±1/2 inch (±12 mm)
o. Bearing plates (center to end): ±1/2 inch (±12 mm)

Flat Wall Panels



a. Length and width:
 ±1/8 inch for less than 10 feet (±3 mm for less than 3m)
 +1/8 inch, -3/16 inch for 10 to 20 feet (+3 mm, -5 mm for 3 to 9 m)
 ±1/4 inch maximum for greater than 30 feet (±5 mm maximum for greater than 9 m)

b. Thickness: +1/4 inch, -1/8 inch (+5 mm, -3 mm)

c. Horizontal and vertical alignment (deviation from straight lines parallel to center line(s) and/or designated skew:
 1/16 inch per 10 feet of length, 1/4 inch maximum (2 mm per 3 m of length, 5 mm maximum)

d. Differential bowing between adjacent members: 1/4 inch (5 mm)

e. Warpage (one corner out of plane with of the other three) 1/4 inch (5 mm)

f. Difference in length of the two diagonal measurements:
 1/8 inch per 6 feet with ¼ inch maximum, ¼ inch square openings and blockouts
 (3 mm per 2 m with 6 mm maximum, 6 mm square openings and blockouts)

g. Position of tendons: ±1/8 inch (±3 mm)

h. Position of reinforcement: ±1/4 inch (±5 mm)

i. Position of haunches: ±1/4 inch (±5 mm)

j. Dimensions of haunches: ±1/4 inch (±5 mm)

k. Haunch bearing surface deviation from specified plane: ±1/8 inch (±3 mm)

l. Difference in relatative position of adjacent haunch bearing surfaces from specified relatative position: ±1/4 inch (±5 mm)

m. Position of openings and blockouts: ±1/4 inch (±5 mm)

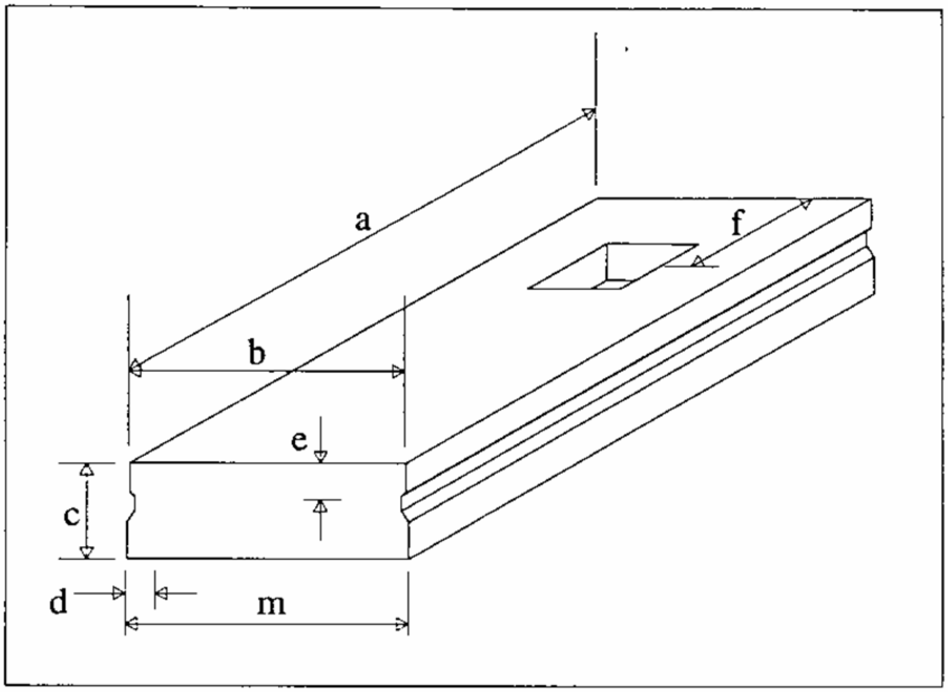
n. Dimensions of openings and blockouts: ±1/4 inch (±5 mm)

o. Position of sleeves and inserts: ±1/4 inch (±5 mm)

p. Position of weld plates: ±1/2 inch (±12 mm)

q. Position of handling devices: ±3 inches (±75 mm)

Precast Deck Units



a. Length: +0, -3/4 inch (+0, -20 mm)
b. Width: ±1/4 inch (±5 mm)
c. Depth: ±1/4 inch (±5 mm)
d. Stem thickness: +1/4 inch, -1/8 inch (+5 mm, -3 mm)
e. Deck thickness: +1/4 inch, -1/8 inch (+5 mm, -3 mm)
f. Position of blockouts: ±1/2 inch (±12 mm)
g. Horizontal alignment (deviation from straight line parallel to centerline of member):
   1/8 inch per 10 feet (3 mm per 3 m)
h. Vertical deviation from design: ±1/8 inch per 10 feet (±3 mm per 3 m)
i. Differential vertical offset between adjacent members of same design:
   ¼ inch per 10 feet, but not greater than ¾ inch (6 mm per 3 m, but not greater than 20 mm)
j. Position of handling devices: ±6 inches (±150 mm)
k. Distance between stems: ±1/4 inch (±5 mm)
l. Position of weld plates: ±1 inch (±25 mm)
m. Squareness of ends (vertical and horizontal alignment): ±1/4 inch (±5 mm)

OMR-CONC. REV. 6/94

GEORGIA D.O.T.
OFFICE OF MATERIALS & RESEARCH
PRECAST/PRESTRESS CONCRETE UNIT
FOREST PARK, GEORGIA

DAILY PRODUCTION REPORT

REPORT NO. ____________

PLANT ☐☐☐ ____________________ JOB NO. ____________

DATE ________ WEATHER ____________ TEMPERATURE: AM _____ °F PM _____ °F.

D.O.T. PROJECT NO. ____________________ COUNTY ____________

BRIDGE NO. ________ PRODUCT ____________ F'c ________ psi F'ci ________ psi

MARK NOS. ________________________________

TENSIONING - ELONGATION DATA

(PLOT STRANDS ON GRID)

BED NO. ____________ BED LENGTH ____________

STRAND SIZE/TYPE ________________________

STRAND MFG. ________________________

MODULUS ____________ psi HEAT # ____________

REEL # ________________________

PRELOAD ____________ lbs RAM ID ____________

CALCULATED ELONGATION

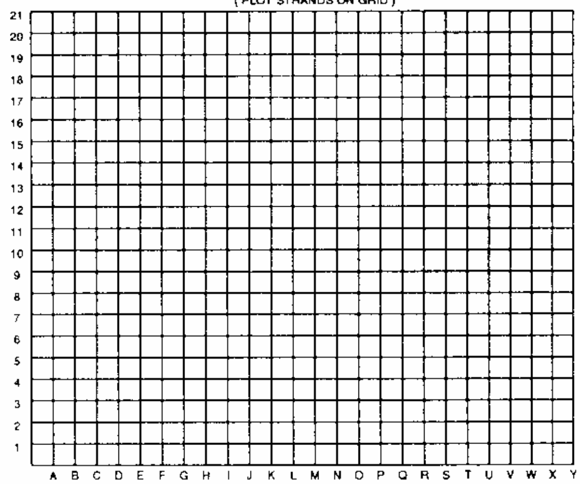
STRAIGHT ________ ins. DRAPED ________ ins

+ 5% ________ + 5% ________
- 5% ________ - 5% ________
+ 5% ________ + 5% ________
- 5% ________ - 5% ________

CALCULATED TENSION

STRAIGHT ________ lbs DRAPED ________ lbs

+ 5% ________ + 5% ________
- 5% ________ - 5% ________
+ 5% ________ + 5% ________
- 5% ________ - 5% ________



TENSIONING REPORT

STR. NO.	GAUGE	ELONG.	STR. NO.	GAUGE	ELONG	STR. NO.	GAUGE	ELONG	STR. NO.	GAUGE	ELONG.

CONCRETE AND CURING INFORMATION

D.O.T. MIX NUMBER:			
MATERIALS		SCALE WEIGHTS	% MOIS.
CEMENT (lbs.)	TYPE		
FLYASH (lbs.)			
SAND (lbs.)			
STONE (lbs.)	SIZE		
WATER (gals.)			
AEA (ozs.)			
HRWR (ozs.)			
OTHER			

NAME OF PERSONS PERFORMING TEST

____
____
____

NO. ____________ ____________
STATION ____________ ____________
TIME ____________ ____________
SLUMP ____________ ____________
% AIR ____________ ____________
PLACEMENT TEMP ____________ ____________

CONCRETE CYLINDERS

CYL. NO.	AGE	PSI

AMBIENT CONCRETE TEMPERATURES

TYPE CURING STEAM ☐ WATER ☐ OTHER ☐

LOCATIONS AND TEMPERATURES

TIME							

Q.C. SUPERVISOR ________________________

DOT-319
REV 8/90

DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS AND RESEARCH
CONCRETE TEST REPORT

SHEET A — 1, 2, 6

REPORT NO. 719476

PCN ____ (11)

CONTRACT NO. ____ (27)

CONCRETE PLANT ____ (40)

CLASS CONCRETE ____ (43)

PROJECT NO. ____ (41)

TOTAL CUBIC YARDS ____ (69)

COUNTY ____ PLANT LOCATION ____ PAY ITEM ____ (73)

CODE	CLASS OF CONCRETE
1	A
2	B
3	AA
4	AAI
5	AAA
6	SEAL
7	CS
8	ACCELERATED
9	PAVEMENT
0	OTHER

CODE	TYPE ADMIXTURE
1	RETARDING
2	WATER REDUCING
3	ACCELERATING
4	OTHER

CODE	TYPE STRUCTURE
01	CULVERT AND END WALL
02	BRIDGE
03	BRIDGE DECK
04	APPROACH SLAB
05	SLOPE PAVING
06	RETAINING WALL
07	CURB AND GUTTER
08	DITCH PAVING
09	MEDIAN
10	MISCELLANEOUS
11	SIDE WALK
12	PRESTRESSED BEAM
13	PRESTRESSED PILE
14	PRECAST BRIDGE
15	PRECAST MISCELLANEOUS
16	PAVEMENT
17	SPECIAL PURPOSE
18	OTHER

MATERIALS	CODE	TYPE	SIZE	SPECIFIC GRAVITY	WEIGHT PER YARD	
CEMENT	76			79	82	
	85			88	91	
FLY ASH (TYPE CODE 1) / SLAG (2)	94			97	100	
SAND 1	103			107	110	114 F/A RATIO
SAND 2	116			120	123	127 F/F RATIO
COARSE AGGREGATE 1	129					
COARSE AGGREGATE 2	142					155 C/C RATIO
WATER					157	GALLONS PER YARD
AIR ENTRAINING					160	PERCENT (%)
OTHER ADMIXTURE	162				165	ADD RATE/YDS

REMARKS ____

SAMPLE NO. 1	SAMPLE NO. 2	DESCRIPTION AND PLACEMENT LOCATION	TYPE STRT	CUBIC YARDS	AIR (%)	SLUMP (IN.)	DATE MADE MO	DAY	YR	AGE DAYS	UNIT LOAD (PSI) CYLINDER 1	CYLINDER 2	LAB NUMBER CYLINDER 1	CYLINDER 2
163	172		176	178	182	184	187			193	196	199		
203	207		211	213	217	219	222			228	230	234		
238	242		246	248	252	254	257			263	265	269		
273	277		281	283	287	289	292			298	300	304		
303	312		316	318	322	324	327			333	336	339		

ABOVE SAMPLES ____ MEET ____ FAIL TO MEET

REQUIREMENTS SECTION ____ EXCEPT NUMBERS LISTED

____ SUBMITTED BY

____ STATE MATERIALS AND RESEARCH ENGINEER

OMR-CONC.

DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS AND RESEARCH
FOREST PARK, GEORGIA

REPORT OF COVER TEST ON
PRECAST/PRESTRESSED CONCRETE

Project No. ____________________

County ____________________

Date Tested ____________________

Reported by: ____________________

Producer: ____________________ Location: ____________________

Type Unit Tested: PRESTRESSED ( ) PRECAST ( )
I Beams ( ) Piling ( ) Box Beams ( ) Bridge Slabs ( ) Bridge Caps ( )
Other ____________________

I.D. NUMBER	DATE CAST	AVERAGE COVER	RANGE MIN.	RANGE MAX.	NUMBER OF TEST	LOCATION OF TEST PERFORMED

REMARKS: ____________________

____

____

____________________ CONCRETE ENGINEER

____________________ DATE REPORTED

PRECAST SHIPPING REPORT
OMR-122
REV. 7/01

GEORGIA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS AND RESEARCH
FOREST PARK, GEORGIA

4604

Contract ID No.: ______________________________

Project No.: ______________________________ County: ______________________________

Date Shipped: ______________ Ticket No.: ______________

Type Unit Shipped: PRESTRESSED ( ) PRECAST ( )

I - Beams ( ) Box Beams ( ) Rect. Beams ( ) Bridge Slabs ( ) Bridge Caps ( ) Bridge Barriers ( ) Piling ( )

Wall Panels ( ) Strain Poles ( ) SIPS [Deck Panels] ( ) Temp. Median Barriers ( ) Other ______________________________

Produced By: ______________________________ Location (City): ______________________________

Bridge No./Wall Location: ______________________________ GDOT or Company Stamp No.: ______________

Product Shipped To (Contractor): ______________________________

QUANTITY	LENGTH	AREA	SIZE OR TYPE	DATE CAST	IDENTIFICATION NUMBER	*STRENGTH

* IF SHIPPED PRIOR TO 28 DAY ACCEPTANCE COMPRESSIVE STRENGTH, ENTER SHIPPING STRENGTH.

Remarks: ______________________________

We, ______________________________ hereby certify that all phases of construction and the materials used to fabricate the above listed units were in accordance with the Plans and the Specifications of the Georgia Department of Transportation.

____
Quality Control Supervisor

____
Notary Public

____
Plant Manager

This the __________ day of ______________, 20 ___

THIS SPACE TO BE FILLED IN BY OFFICE OF MATERIALS AND RESEARCH

Remarks: ______________________________

____

Meets the requirements of Article __________

Report No.:

____
Technical Services Engineer/Technician

____
State Materials and Research Engineer

GEORGIA DEPARTMENT OF TRANSPORTATION
STUDY GUIDE FOR CONCRETE TECHNICIANS

I. Procedure for Selecting Proportions

A. Establishing Limiting Criteria

Before starting to establish mix proportions, information must be assembled on the characteristics of Department approved materials and the requirements of the concrete. Information on materials should include:

1. Relationships of strength to water/cement ratio for available combinations of materials, including cement.
2. Specific gravities and absorptions of fine and coarse aggregates.
3. Gradings of fine and coarse aggregates.
4. Effects of any admixtures to be used, and addition rates.

B. The job Specification, or other sources of information should be examined in detail to ascertain requirements for:

1. Maximum water/cement ratio
2. Minimum cement factor
3. Air content
4. Slump
5. Maximum size of aggregate and limitations or grading
6. Strength
7. Required admixtures

C. In the case of Department of Transportation work, the second list of criteria will govern. This information can be found on the chart containing uses of concrete in the Standard Specifications.

II. Definition of Terms

Before you begin proportioning, it would be helpful to review the terms and definitions as follows:

1. Specific Gravity. The specific gravity of a material is expressed as a ratio of its weight to the weight of the same volume of water.

   Specific gravity of water is equal to one.

   The specific gravity of cement is equal to 3.14; or we could say (cement is 3.14 times as dense as water).
2. "Solid" weight per cubic foot. The solid weight per cubic foot of a material is expressed as the product of the materials specific gravity times the weight of one cubic foot of water (62.4 lbs).

   The solid weight per cubic foot of cement is equal to:

   $3.14 \times 62.4\,\text{lbs} = 195.94\,\text{lbs}/\text{ft}^3$

3. Absolute Volume. The absolute volume of a material is the volume exclusive of the void spaces between particles. It is expressed as the ratio of the loose materials weight to the solid weight per cubic foot of the same material.

One sack of cement (94 lbs) occupies approximately one cubic foot of bulk volume, but the absolute volume of the solid cement particles is only about 0.48 ft^3.

$$\frac{94\,\text{lbs}}{195.94\,\text{lbs}/\text{ft}^3} = 0.48\ \text{ft}^3$$

III. Determining Proportions

Determination of proportions can best be done by establishing a list of requirements needed in finding proportions and then fulfilling these requirements according to the Specifications.

1. Selection of Cement Factor

   The Department of Transportation has already established a minimum cement factor for all classes of concrete. This factor can be obtained from the Specifications.

2. Determining Mix Water Requirement

   The Department of Transportation has established a maximum amount of water for a given amount of cement. Actual mixing water required to produce the desired slump will be somewhat less than the maximum. Even though tables have been established which can aid in determining the actual amount of mixing water needed for certain size and shape aggregates and corresponding slump values, we must rely largely on experience. Therefore, a concrete technician who works with a given combination of materials daily should be familiar enough with his materials to determine the actual mixing water required.

3. Specific Gravities

   Specific gravities can be obtained from the List of Approved Aggregate Sources (QPL 1 & 2) published by the Department.

4. Determination of Aggregate Volume

   In determining the ratio of fine aggregate volume to coarse aggregate volume, we must again rely on experience or other acceptable published design procedures. This should be easy enough for a concrete technician who is familiar with the characteristics of the material he is using.

5. Allowance for Volume of Air

   The Specification establishes the design air content and a range of air contents for all Classes of concrete used by the Department. These volumes of air should be taken into consideration in your design.

IV. Example Problems

Example 1: Establish the proportions for a Class "A" mix using the following materials:

Materials	Sp. Gr.	Absorption	Solid Wt./ft^3
Medusa Cement	3.14		$3.14 \times 62.4 = 195.94$
Howard Sand	2.61	0.43	$2.61 \times 62.4 = 162.86$
Dalton Rock	2.74	0.62	$2.74 \times 62.4 = 170.98$

			Volumes	
Cement	611		3.12	ft^3
Sand	1168		7.17	ft^3
Stone	1918		11.22	ft^3
Water	33.0	gals.	4.41	ft^3
Air	4 %		1.08	ft^3
	Total Volume =		27.00	ft^3

$$\text{Absolute Vol.} = \frac{\text{Weight}}{\text{Solid Wt.}/\text{ft}^3}$$

$$\text{Absolute Vol. Cement} = \frac{611\text{ lbs}}{195.94\text{ lbs}/\text{ft}^3} = 3.12\text{ ft}^3$$

$$\text{Absolute Vol. Water} = \frac{33.0\text{ gals} \times 8.33\text{ lbs}/\text{gal}}{62.4} = 4.41\text{ ft}^3$$

$$\text{Absolute Vol. Air} = 27.00 \times 0.04 = 1.08\text{ ft}^3$$

$$\text{Total Vol. of Cement, Water, Air} = 8.61\text{ ft}^3$$

$$\text{Total Vol. Aggregate} = 27.00 - 8.61 = 18.39\text{ ft}^3$$

$$\text{Volume of Sand} = 18.39 \times 0.39 = 7.17\text{ ft}^3$$

$$\text{Volume of Stone} = 18.39 - 7.17 = 11.22\text{ ft}^3$$

$$\text{Batch Weights} = \text{Absolute Volume} \times \text{Solid Wt.}/\text{ft}^3$$

$$\text{Batch Wt. Sand} = 7.17 \times 162.86 = 1168\text{ lbs}$$

$$\text{Batch Wt. Stone} = 11.22 \times 170.98 = 1918\text{ lbs}$$

Example 2: Listed below are the one cubic yard proportions for a Class A concrete mix. It has been determined that this mix produces concrete that has excessive slump (6.0"). Reduce the water by 2.0 gallons per cubic yard and make the necessary adjustment in the sand so as to keep the same volume of concrete. Remember, in general, one gallon of water per cubic yard will change slump measurements approximately 1.0 inch.

Materials	Proportions (lbs)		Sp. Gr.	Absolute Vol. (ft^3)	Adjusted Proportions	
Cement	611		3.14	3.12	611	lbs
Sand	1155		2.63	7.39	1199	lbs
Stone	1898		2.66	11.14	1898	lbs
Water (gals)	(34.0)	32.0		4.27	32.0	gals
Air	4 %			1.08		

Reduce water by 2 gallons = 34.0 - 2.0 = 32.0

$$\text{Absolute Vol. Cement} = \frac{611\ \text{lbs}}{195.94\ \text{lbs}/\text{ft}^3} = 3.12\ \text{ft}^3$$

$$\text{Absolute Vol. Water} = \frac{32.0\ \text{gals} \times 8.33\ \text{lbs/gal}}{62.4\ \text{lbs}/\text{ft}^3} = 4.27\ \text{ft}^3$$

$$\text{Absolute Vol. Stone} = \frac{1898\ \text{lbs}}{170.35\ \text{lbs}/\text{ft}^3} = 11.14\ \text{ft}^3$$

$$\text{Absolute Vol. Air} = 27.00 \times 0.04 = 1.08\ \text{ft}^3$$

Total Volume of Cement, Water, Stone, Air = 19.61 ft^3

$$\text{Volume of Sand} = 27.00 - 19.61 = 7.39\ \text{ft}^3$$

Adjusted Proportions

$$\text{Cement} = 3.12 \times 195.94 = 611\ \text{lbs}$$

$$\text{Sand} = 7.39 \times 162.24 = 1199\ \text{lbs}$$

$$\text{Stone} = 11.14 \times 170.35 = 1898\ \text{lbs}$$

Example 3: Listed below are the proportions for a Class B concrete mix. It has been determined that the mix will not produce workable concrete because of a lack of sand. Increase the sand by 110 pounds per cubic yard and make no changes in the cement, water, and air. Retain the same volume of concrete which is one cubic yard.

Materials	Proportions (lbs)		Sp. Gr.	Absolute Vol. (ft^3)	Adjusted Proportions	
Cement	470		3.14	2.40	470	lbs
Sand	1063		2.63	7.15	1173	lbs
Stone	2075		2.66	11.83	1964	lbs
Water	34.0	gals		4.54	34.0	gals
Air	4 %			1.08	4	%

$$\text{Add } 110\ \text{lbs to sand weight} = 1063\ \text{lbs} + 110\ \text{lbs} = 1173\ \text{lbs}$$

$$\text{Absolute Vol. Sand} = \frac{1173\ \text{lbs}}{164.11\ \text{lbs}/\text{ft}^3} = 7.15\ \text{ft}^3$$

$$\text{Absolute Vol. Cement} = \frac{470\ \text{lbs}}{195.94\ \text{lbs}/\text{ft}^3} = 2.40\ \text{ft}^3$$

$$\text{Absolute Vol. Water} = \frac{34.0\ \text{gals} \times 8.33\ \text{lbs/gal}}{62.4\ \text{lbs}/\text{ft}^3} = 4.54\ \text{ft}^3$$

$$\text{Absolute Vol. Air} = 27.00 \times 0.04 = 1.08\ \text{ft}^3$$

Total Volume of Sand, Cement, Water, Air = 15.17 ft^3

$$\text{Absolute Volume of Stone} = 27.00 - 15.17 = 11.83\ \text{ft}^3$$

<u>Adjusted Proportions</u>

$$\text{Stone} = 11.83 \times 165.98 = 1964\ \text{lbs}$$

Example 4: The one cubic yard mix proportions listed below will not produce concrete of the desired consistency on the job. Increase the water by 1.5 gallons per yard and keep the same coarse to fine aggregate ratio.

Materials	Proportions (lbs)	Sp. Gr.	Absolute Vol. (ft^3)	Adjusted Weights
Cement	611	3.14	3.12	611 lbs
Sand	1193	2.66	7.09	1177 lbs
Stone	1894	2.71	11.10	1877 lbs
Water (gals)	33.0 gals		4.61	34.5 gals
Air	4 %		1.08	4 %

Determine coarse to fine aggregate ratio by volume.

$$\text{Sand} = \frac{1193\ \text{lbs}}{165.98\ \text{lbs}/\text{ft}^3} = 7.19\ \text{ft}^3$$

$$\text{Stone} = \frac{1894\ \text{lbs}}{169.10\ \text{lbs}/\text{ft}^3} = 11.20\ \text{ft}^3$$

$$\%\ \text{fine aggregate to coarse} = \frac{7.19\ \text{ft}^3}{18.39\ \text{ft}^3} = 0.39 \times 100 = 39\%$$

$$\text{Increase water 1.5 gallons} = 33.0 + 1.5 = 34.5\ \text{gallons}$$

$$\text{Absolute Vol. Water} = \frac{34.5\ \text{gals} \times 8.33\ \text{lbs/gal}}{62.4\ \text{lbs}/\text{ft}^3} = 4.61\ \text{ft}^3$$

$$\text{Absolute Vol. Cement} = \frac{611\ \text{lbs}}{195.94\ \text{lbs}/\text{ft}^3} = 3.12\ \text{ft}^3$$

$\text{Absolute Vol. Air} = 27.00 \times 0.04 = 1.08 \ \text{ft}^3$

Total Absolute Vol. of Cement, Water, Air = 8.81 ft^3

$\text{Total Absolute Volume of Aggregate} = 27.00 - 8.81 = 18.19 \ \text{ft}^3$

$\text{Absolute Vol. of fine aggregate} = 18.19 \ \text{ft}^3 \times 0.39 = 7.09 \ \text{ft}^3$

$\text{Absolute Vol. of coarsee aggregate} = 18.19 \ \text{ft}^3 - 7.09 \ \text{ft}^3 = 11.10 \ \text{ft}^3$

Adjusted Weights

$\text{Cement} = 3.12 \times 195.94 = 611 \text{ lbs}$

$\text{Sand} = 7.09 \times 165.98 = 1177 \text{ lbs}$

$\text{Stone} = 11.10 \times 169.10 = 1877 \text{ lbs}$

Water = 34.5 gallons

Air = 4.0 %

Example 5: Listed below are the proportions for a Class A concrete mix. The contractor has elected to use a fly ash mix with a 15% cement reduction and a 1.25 lbs. to 1.0 lb. replacement factor. Make this adjustment and maintain the same stone, water, and air volume.

Materials	Proportions (lbs)	Sp. Gr.	Absolute Vol. (ft^3)	Adjusted Weights
Cement	611	3.14	2.65	519 lbs
Fly Ash	0	2.40	0.77	115 lbs
Sand	1193	2.66	6.89	1144 lbs
Stone	1894	2.71	11.20	1894 lbs
Water (gals)	33.0 gals		4.61	33.0 gals
Air	4 %		1.08	4 %

Determine the amount of cement and fly ash required.

$$\text{Cement} = 611 \times 0.15 = 92.0 \text{ lbs}$$

$$611 - 92.0 = 519 \text{ lbs}$$

$$\text{Fly Ash} = 92 \times 1.25 = 115 \text{ lbs}$$

$$\text{Absolute Vol. Cement} = \frac{519 \text{ lbs}}{195.94 \text{ lbs/ft}^3} = 2.65 \text{ ft}^3$$

$$\text{Absolute Vol. Fly Ash} = \frac{115 \text{ lbs}}{149.76 \ \text{lbs/ft}^3} = 0.77 \text{ ft}^3$$

$$\text{Absolute Vol. Stone} = \frac{1894 \text{ lbs}}{169.10 \text{ lbs/ft}^3} = 11.20 \text{ ft}^3$$

$$\text{Absolute Vol. Water} = \frac{33.0 \text{ gals} \times 8.33 \text{ lbs/gal}}{62.4 \text{ lbs/ft}^3} = 4.41 \text{ ft}^3$$

$\text{Absolute Vol. Air} = 27.00 \times 0.04 = 1.08 \text{ ft}^3$

Total Absolute Vol. of Cement, Fly Ash, Stone, Water, Air = 20.11 ft^3

$\text{Absolute Volume of Sand} = 27.00 - 20.11 = 6.89 \text{ ft}^3$

<u>Adjusted Batch Weights</u>

$\text{Cement} = 2.65 \times 195.94 = 519 \text{ lbs}$

$\text{Fly Ash} = 0.77 \times 149.76 = 115 \text{ lbs}$

$\text{Sand} = 6.89 \times 165.98 = 1144 \text{ lbs}$

$\text{Stone} = 11.20 \times 169.10 = 1894 \text{ lbs}$

Water = 33.0 gallons
Air = 4.0 %